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Health Effect Assessment of Agricultural Burning Smoke in Pullman

The Northwest Center for Particulate Air Pollution and Health
University of Washington and Washington State University
L.-J. S. Liu (sliu@u.washington.edu), C Claiborn, J Kaufman, J Koenig, J Sullivan, and C Trenga

Background

Agricultural (Ag) burning of residues is a traditional method of cleaning, reviving, and preparing the field for the coming growth season (Mazzola et al., 1997). It is an inexpensive and easy means of agricultural practice. Wheat growers in eastern Washington and northern Idaho burn wheat stubble that remains in the fields after the wheat is harvested. In fall 2000 and spring 2001, a total of 177,346 acres of cereal grain were burned in eastern Washington (DOE, 2001). Burning reduces the amount of pesticides that must be applied to control insects, nematodes, and weeds. Burning also makes it unnecessary to till, thereby reducing airborne dust and erosion of soil into water. However, smoke from Ag burning may contain various air pollutants, including particulate matter (PM), nitrogen dioxide (NO_2), CO, and a series of semi-volatile and volatile organic compounds (Bouble et al. 1969). Inhalation of these air pollutants could result in respiratory diseases. However, because Ag burning smoke may consist of more organic matter than urban air pollution, the dose-response relationship for Ag burning smoke health effects is still unknown. Only a handful of studies have examined respiratory effects of Ag burning smoke in neighboring communities. Jocobs and coworkers (1997) studied rice burning and asthma hospitalizations in Butte County, CA. Their study shows links between acreage burned and the risk of hospitalization. However, peak burning acreage was not correlated with O_3, CO, and PM_{10} measured at sites operated by the California Air Resource Board. Torigoe and coworkers (2000) reported a correlation between PM_{10} and the number of children with asthma attacks, with the increase in PM_{10} most likely due to the influence of emission from rice straw burning. Norris and coworkers (2000) reported that the products of incomplete combustion are the air pollutants associated with increases in emergency department visits for asthma in both Spokane and Seattle. However, they could not discern the exact combustion related pollutants from their data.

Goal

No study has been conducted to examine community residents' exposures to Ag burning smoke and the related health effects on a short-term basis. The ultimate research question that we attempt to answer is: Are episodes of increased particulate matter air pollution from agricultural burning associated with health effects in asthmatics, as measured by:

- decrement in forced expiratory volume in one second (FEV_1)?
- increase in exhaled nitric oxide (eNO)?
- increase in asthmatic symptoms and/or use of rescue medications?

This proposed project will accomplish the above goal in three phases. The first phase is to design a study with sample size calculations that utilize exposure estimates and health effect results from our previous studies on wood smoke and biomass burning. The second phase of the project is to implement such a study, while the last phase is to analyze samples and data.

Study Population and Location

The study location not only needs to be impacted by Ag burning smoke but also sufficiently large for subject recruiting purposes. Ideally, the study site should have resources and infrastructure in place to provide historical PM concentrations, ambient monitoring capability, and laboratory space for both sampler preparation and health effect tests. The study subjects need to be in a sensitive population that has been known to demonstrate a certain degree of adverse health effects in polluted air. The population should be able to comply with the study protocol.

Children with asthma is a sensitive population, however, there are several concerns regarding studying children's health effects from Ag burning smoke: 1) It is usually difficult to obtain consistent lung function test measurements from children. Even if children can give consistent health measures, they have dynamic growth curve in their lung function, which complicates the study results. 2) Children are probably more likely to be on corticosteroid therapy since parents are likely to seek out the best therapy. Adults who have been living with asthma all their life may not be aware of the latest therapies, especailly if they are being treated by a general physician and not an asthma specialist (Adams et al. 2002). Young asthmatic subjects on corticosteroid are not sensitive to air pollution exposure as compared to older asthmatic subjects (Jane Koenig, unpublished data). 3) Compliance of children in the exposure and health effect monitoring protocols is usually low. 4) Recruiting asthmatic children only in the study may stigmatize these children. To include other children will double the study cost. 5) It is important to take lung function measurements at the same time of the day. However, it is difficult to recruit the required number of children who can either be home or visit the lab to perform such tests at the same time daily.

Thus, we selected adults with asthma in the Washington State University community. They are usually active and health effects observed in such a population can be generalized to asthmatics of younger ages. In addition, there is an excellent infrastructure for supporting air monitoring at WSU. $PM_{2.5}$, PM_{10}, and other air pollutants have been continuously monitored for several years at WSU. Lab space is available to support monitoring activities and (clinic) lab visits. Graduate students and professional staff have been trained in Spring 2002 in a Ag burning pilot study for air pollution field monitoring and health effect assessment. Thus our selection criteria are:

- Adults, male or female, aged 18-65, in the WSU community, Pullman, WA.
- Physician-diagnosed mild to moderate asthma
- With or without inhaled corticosteroid use, but prefer those without

Recruitment/Screening

Subject recruiting usually takes several weeks to months, depending on the required number of subjects needed, available population size, inclusion criteria, enthusiasm of the population, available resources for advertisement, and cooperation from the local health care providers. In selecting WSU, we have access to the campus and local clinics, dormitories, student activity centers, etc. Mandatory gathering of students for the orientation during early August further facilitates recruiting. It is also possible to recruit from graduate students and staff.

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Study Period

The study period needs to be able to capture frequent smoke events. Historically, more acreages were burned per burn day in the fall and more air pollution episodes were observed during the fall burning season than the spring burning season. Thus, the selected monitoring period is August - October, 2002

Study Design

1. Health Effect Assessment

Statistical power calculations were made based on the health effect results from our Seattle panel study (Oct 99-May 01) (Liu et al. 2002) and the variability and level of Ag burning smoke episodes in Eastern Washington in the past three years. At least 30 days of monitoring on at least 24 subjects are necessary to detect a significant reduction in pulmonary lung function (in FEV_1) or exhaled nitrous oxide (eNO) among sensitive populations. This assumes a 10% chance of observing an episode with $PM_{2.5}$ concentration > 50 $\mu g/m^3$. Thus, a longitudinal study design that follows a sensitive cohort for an extensive period of time has the highest potential to encompass an Ag burning episode and detect health effects.

- Longitudinal cohort "panel" study with repeated measures for each individual
- 2 sampling periods, including active and "on-call" periods, 4 weeks each
- 16 subjects in active monitoring during each 4 wk study block, 32 subjects total
- All subjects (whether or not in active monitoring) remain "on-call" during entire eight-week duration of study, and report to the study center during burn episode and subsequent 2 days.
- Health outcomes measured in three time frames:
    1. 3 times per week during active monitoring phase (technician-measured)
        - spirometry (PFT), includes assessment of FEV_1
        - eNO
    2. 4 times per day, 7days per week during active monitoring phase (self-measured): upon awakening, before lunch, before dinner, before retiring:
        - PFT
        - symptom diary
    3. 1 time per day for the "on-call" subjects during episode and subsequent 2 days (technician-measured)
        - PFT
        - eNO
- Study center monitoring at same time each day for each subject to control for circadian rhythms
- Lab visits also include diary review, evaluation of PFT technique & data, and PFT data downloading.
- Subjects in the active monitoring phase will bring first morning void on M/W/F; urine will be used to assess exposure-related biomarkers.
- eNO and spirometry conducted according to American Thoracic Society guidelines.

2. Episode Declaration

We expect that there will be up to three Ag burning episodes during the study period. In addition, we will call up to two sham episodes as controls. The definition of an episode includes: 1) there are burn calls in Washington or Idaho during the day, AND 2) there are visual signs of smoke, AND 3) biomass burning smoke can be smelled in town, AND 4) the real-time $PM_{2.5}$ monitor shows at least a few spikes (>40 $\mu g/m^3$). For the sham episodes, we hope to include one dust storm episode (where $PM_{2.5}$ is only 10-20% of PM10 levels), which is not uncommon during the fall burning season.

3. Exposure Assessment

Literature has shown that personal exposures to air pollution are different from measurements taken at centrally located sites (Liu et al. 2002). Central site measurements are not representative of personal exposures. The ideal exposure assessment would be to conduct personal exposure monitoring. However, daily personal air pollution monitoring for an extensive period is very expensive and subject compliance is very questionable. Based on results from our previous personal exposure assessment studies (Ryan et al. 2002), personal exposures to outdoor originated pollutants can be estimated based on some essential information. This includes the time-activity diary, house ventilation condition diary, continuous indoor and outdoor PM measurements, as well as biomarkers in urine specimen. Such modeled exposures should always be validated with randomized personal exposure measurements in the field.

- Personal Exposure
  - Subjects will be give urine samples twice a day for 30 days during the active monitoring phase: first void of the day and last void before bedtime.
  - All subjects will record their time-activities on a diary and keep a dietary diary.
  - At any time, up to two (intensive) subjects will be carrying personal samplers that measure $PM_{2.5}$ mass using the Harvard personal environmental monitors for $PM_{2.5}$ ($HPEM_{2.5}$). One $HPEM_{2.5}$ will contain a Teflon filter for filter weight and X-ray fluorescence analyses for a suite of 55 elements, and the other $HPEM_{2.5}$ will contain a quartz filter for elemental carbon and organic carbon analysis. The elemental, EC, and OC concentrations, along with the urine analysis results, will be used for source apportionment and for validation of results from our source contribution model (Ryan et al. 2002).
- Indoor Exposure
  - One light scattering device, either a Radiance nephelometer or anMIE personal DataRAM, will be placed inside each subject's residence
- Outdoor exposure will be monitored as described in the table below. The central site is located on top of the Engineering building at WSU. Other outdoor sites will include two on-campus sites (in one of the dormitories and on the other side of the WSU campus hill), one downtown Pullman site (in the valley), and up to five home outdoor sites that will best take into account the topologic features of Pullman (ridges, valleys, and different sides of the four hills). Some possible locations are shown as filled circles in the attached topographic map (Attachment 1).

Detailed exposure monitoring schedule is shown in Table 1.

Table 1. Detailed monitoring plan for the Ag Field Burning Study, Autumn 2002

Parameter	Active Group, **ALL** (16 subj/day, **3 lab visits/wk**)	Intensive Subjects (2 subj/day; 5 consecutive 24-hr days)	On-call group (16 subj/d, 3 lab visits/**episode**)	Indoors at ALL active subjects' homes	Central location (1 site, every day, 12-hr samples)
$PM_{2.5}$	---	---	-	---	HIFT (10 L/min)*
PM_1	---	PDR/Hobo #	-	Nephelometer	Nephelometer
WS markers	Urine (2/day; episode week only)	HPT (4 L/min) * ←daily	Urine (2/day; episode week only)	---	HIFT (10 L/min)
EC/OC	---	HPQ (4 L/min) *	-	---	HIXQ (10 L/min)*
NO	Breathe into analyzer	←	Breathe into analyzer		(TBD)
CO	Breath collection bag	←	Breath collection bag	-	-
CO_2 (air change)	---	---	---	TelAir	TelAir
Aldehydes					Active Sep-Paks*
RH, continuous	---	-	---	Hobo	Hobo
Temperature, continuous	---	-	---	Hobo	Hobo
Activities/ Medications	Home Characteristics Time Activity Diary; Asthma & medications, smoke food dietary diary	Daily Follow-up; SF dietary diary ←daily	Home Characteristics Time Activity Diary; Asthma & medications, smoke food dietary diary	---	---
Pulmonary function	Micro DL (spirometry)	Micro DL (spirometry)	Co-Co	---	---

* indicates measurement with field blank.

personal pDR only if subject willing to carry in addition to HPT and HPQ

Sample Labeling Convention (as shown in Table 1)

Subject ID's will be designated as B01 through B32. The active subjects in the first session will be subject numbers 01 to 16, while those initially on-call but active during the second session starting October 3 will be designated B17 to B32. Central site samples are assigned a subject ID of BC1 for days 1 to 30, and BC2 for the second session with days 31 to 60. All samples must be labeled correctly **before** leaving the laboratory or deploying them during a subject lab visit. Each sample label consists of four pieces of information: sample type, location, subject ID, and the day number of monitoring.

Sample type codes include:

HPT	Harvard PEM with Teflon filter
HPQ	Harvard PEM with Quartz filter
PMT	P-POMS sampler with carbon foam and Teflon filter
PMQ	P-POMS sampler with carbon foam and Quartz filter
HIFT	Harvard Impactor (HI), for PM2.5 (fine) particles, with Teflon filter
HIFQ	Harvard Impactor (HI), for PM2.5 (fine) particles, with Quartz filter (EC/OC)
HIMQ	Harvard Impactor (HI), for PM2.5 (fine) particles, with foaM + Quartz (EC/OC)
HIXQ	HI, for $PM_{2.5}$ particles, with quartz filter (use X {nothing} if also using foaM)
CO	CO
NO	NO
UR	Urine sample
PDR	Personal DataRAM
NP	Nephelometer (PM_1)
CO2	CO_2
T	Temperature
RH	Relative humidity
NT	Nephelometer inlet temperature and relative humidity (used at central site only)

Personnel

This study will be a collaboration effort between University of Washington and Washington State University. Dr. Liu of University of Washington, principle investigator, will supervise study implementation, data collection, quality control, sample analysis, data analysis, and report preparation. Dr. Claiborn of Washington State University, co-PI, will be in charge of field work, chemical analysis, data analysis, and manuscript preparation. Drs. Kaufman and Sullivan of University of Washington, will be in charge of quality control and health data, data interpretation and analysis.

References

Adams RJ, Fuhlbrigge A, Guilbert T, Losano P, Martinez F. Inadequate use of asthma medication in the United States: Results of the Asthma in America national population survey. J Allergy Clin Immunol. 110:58-64.(2002).

Bouble, R.W.; Darley, E.F.; Schuck, E.A. Emissions from burning grass stubble and straw. J. Air Pollution Control Assoc. 19: 497-500 (1969).

Department of Ecology, 2001 Agricultural Statistics except barley.

Jacobs J, Kreutzer R, Smith D. Rice Burning and Asthma Hospitalizations, Butte County, California, 1983-1992. Environmental Health Perspectives 105:980-985(1997).

Liu, L.-J. Sally, Michael Box, David Kalman, Joel Kaufman, Jane Koenig, Tim Larson, Thomas Lumley, Lianne Sheppard, and Lance Wallace. Exposure Assessment of Particulate Matter for Susceptible Populations in Seattle, WA. Submitted to Environmental Health Perspectives, September 2002.

Mazzola, M.; Johnson, T.E.; Cook, R.J. Influence of field burning and soil treatments on growth of wheat after Kentucky bluegrass, and effect of Rhizoctonia crealis on bluegrass emergence and growth. Plant Pathology 46: 708-715 (1997).

Norris G, Larson T, Koenig JQ, Claiborn C, Sheppard L, Finn D. Asthma Aggravation, combustion, and stagnant air. Thorax 55(2000).

Allen R, Larson T, Sheppard L, Wallace L, Liu L-JS. Investigation of Indoor and Outdoor Contributions to Total Indoor Particulate Matter Exposure. Environmental Science & Technology:Submitted(2002).

Torigoe K, Satoshi H, Numata O, Yazaki S, Matsunaga M, Boku N, Hiura M, Ino H. Influence of emission from rice straw burning on bronchial asthma in children. Pediatrics International 42:143-150(2000).

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Budget Justification (11/1/2002-10/31/2003)

Personnel: $50,902

- Dr. L.-J. Sally Liu, Principle Investigator, 10% effort, $8,428
- Dave Hardie, research technologist for sample analysis and data processing, 50% effort, $13,494.
- Phuong Tran, lab assistant for sample preparation, filter weighing, and data entry, 50% effort, $11,520.
- Michael Compher, graduate research assistant, data analysis, 50% effort, $17,460.

Fringe Benefits: $8,575

- Liu @ 22.3%, total $1,879.
- Hardie, classified staff @ 26.2%, $3,535.
- Tran, hourly employee @ 9.7%, $1,117.
- Compher, graduate student @ 11.7%, $2,043.

Supplies: $1,000

Glassware, solutions, and chemical reagents for aldehyde sample analysis.

Other Expenses: $30,280

Copying of field logs: $1,000
Shipping of samples and monitors between Seattle and Pullman: $1,000
Urine sample analysis for biomass burning smoke markers @ $110/sample*2 samples/day * 2 subjects/day * 60 days * 50% of total samples = $13,200
X-ray fluorescence analysis for a suite of 55 elements: $65/sample * 60 samples (1/3 of total sample size) *1.2 (20% blanks and duplicates) = $4,680.
Aldehyde analysis fee: $25 * 60 samples *1.4 (40$ blanks and duplicates) = $2,100
Graduate operation fee (student tuition) $7,100
Publication costs $1,200

Travel: $0

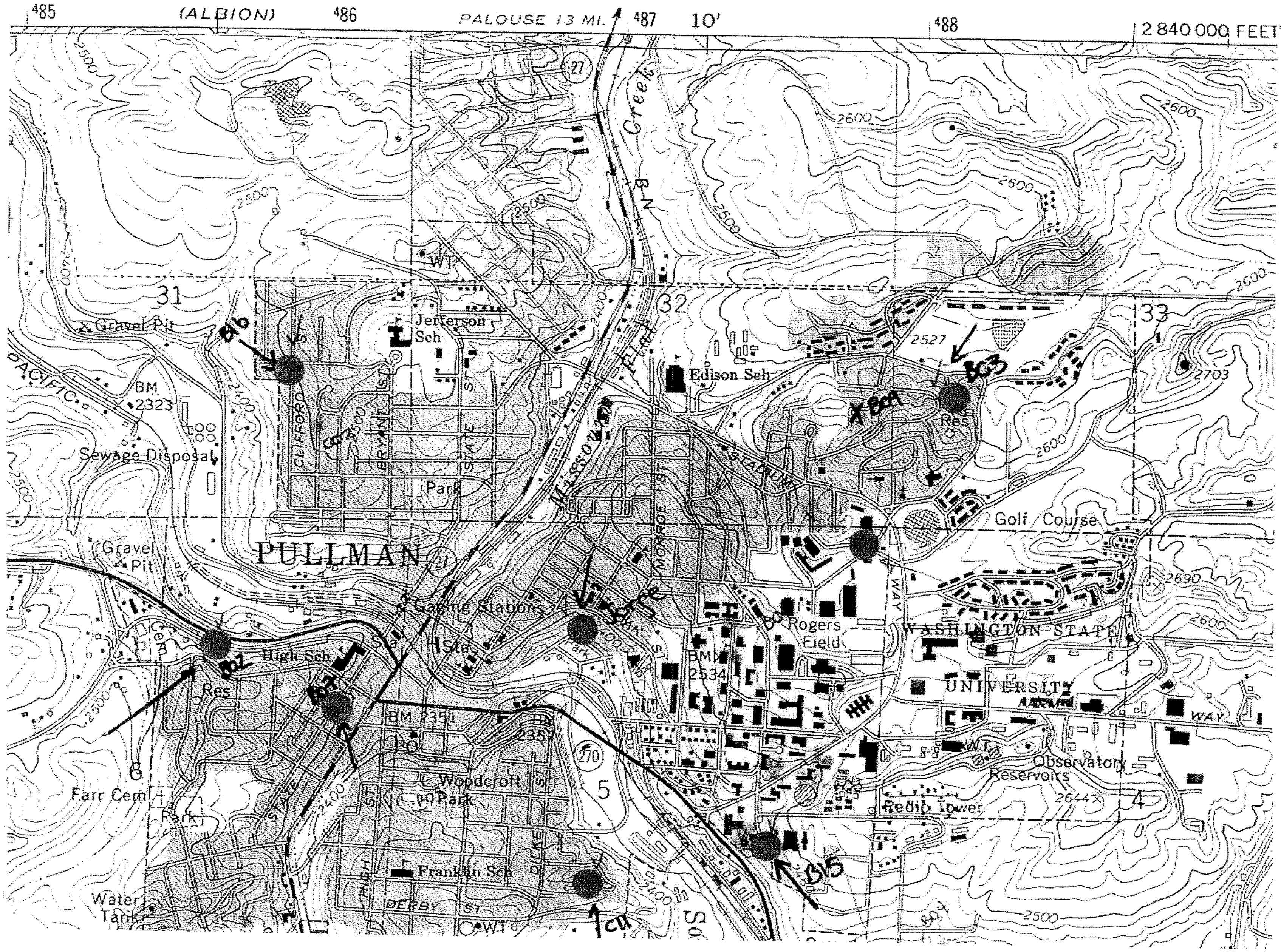
Subcontract with Washington State University: $79,048
See Attachment 2 for the cost breakdown.

Total Direct Cost: $169,805

Indirect Cost, off campus rate @ 26% (less graduate operation fee and subcontract, plus 26% of first $25,000 in subcontract costs) = $28,251

Total Cost: $198,056. (This proposed study is being leveraged with the PM Center supports, see Attachment 3)

Attachment 1. Possible outdoor monitoring sites in Pullman.



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Attachment 2. Cost Breakdown for the WSU subcontract

AGENCY: UW **P.I. NAME:** Claiborn, C. **TIME REQUESTED:**

			Year 1	TOTAL
PERSONNEL				
NAME				
Claiborn, C.		**Salary**	7,834	7,834
	1 month	*Benefits*	2,115	2,115
Bamesberger, L.		**Salary**	5,980	5,980
	260 hrs	*Benefits*	1,615	1,615
Finn, D.		**Salary**	-	-
	3 months	*Benefits*	-	-
Hoffman, M.		**Salary**	6,010	6,010
	433 hrs	*Benefits*	1,623	1,623
GRA				
1 RA-II		**Salary**	7,689	7,689
	1 year	*QTR*	3,065	3,065
		Health	571	571
		1.5% Med	115	115
TOTAL SALARY/WAGES			27,513	27,513
TOTAL BENEFITS			9,104	9,104
TOTAL PERSONNEL			36,617	36,617
MATERIALS & SUPPLIES				
Supplies			1,850	1,850
Publication Costs				-
				-
Total Supplies			1,850	1,850
TRAVEL				
Domestic			2,000	2,000
Foreign				-
Total Travel			2,000	2,000
OTHER COSTS				
IOGAPS analysis fee			15,000	15,000
Phone, postage				-
GRA		*QTR*	-	-
Total Other Direct Costs			15,000	15,000
TOTAL DIRECT COSTS			55,467	55,467
INDIRECT COSTS				
Exclusions		45%		
QTR			3,065	3,065
Equipment			-	-
Subcontract	45% of $25,000			
Total Indirect Costs			23,581	23,581
TOTAL PROJECTS COSTS			79,048	79,048

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Attachment 3: Supports from the NW PM Center (July 1, 2002-Oct 31, 2002)

FROM	7/1/2002		Through		10/31/2003		
Personnel			Time Effort		Dollar Amount Requested (omit cents)		
NAME	Title or Position	Role in Project	%	Hours/Week	Salary	Fringe Benefits	Totals
Sally Liu	Assitant Professor	PI	10%	4	$ 8,428	$ 1,879	$ 10,308
Joel Kaufman	Associate Professor	Co-PI	10%	4	$ 11,000	$ 2,453	$ 13,453
C. Marquist	Research Scientist	Proj Coordinator	20%	8	$ 7,600	$ 1,862	$ 9,462
C. Trenga	Research Scientist	Research associate	10%	4	$ 5,500	$ 1,348	$ 6,848
Jeff Sullivan	Research Physician	Research associate	10%	4	$ 8,500	$ 2,083	$ 10,583
				Subtotals	$ 41,028	$ 9,624	$ 50,653

Supplies (itemized)				
Sep-Paks ($5 * 2/day * 60 days)	$ 600	urine collection cups:		
Glassware, solutions, chemical agents	$ 1,000	($0.5*32 subj*2/day*14 d)	$ 448	
Teflon filters (120*1.2*2=288 or 300)	$ 1,500	T/RH loggers $120*6	$ 720	$ 4,268
Equipment (itemized)				
NO analyzer (model 280i NOA) plus misc. expenses			$ 21,838	
Micro DL @ $995 x 12 + shipping			$ 12,240	
KoKo Peaks @ $72 * 32 + shipping			$ 2,807	
Laptop computer w/modular bays			$ 2,500	
MicroCheck 1-way MP (200) @ $64 x 2			$ 128	
Miscellaneous			$ 500	$ 40,013
Other Expenses (itemized)				
Copying (logs, Questionnaires, dups)	$ 1,000	1 Cell phones for field coordination	$ 200.00	
Shipping (samples, instruments)	$ 1,000	Urine Sample Analysis ($90/smp)	$ -	
labels and carbon tapes	$ 500	XRF analysis ($65/sample)	$ -	
Graduate operating fee	$ -	Aldehyde analysis $10/sample*120	$ -	
Subjects Compensation (Incentives)				
Screening @ $20 * 50 subjects			$ 1,000	
"Active" subjects @ $25 * 12 visits * 32 subjects			$ 9,600	
"Episode-based" subjects @ $25 * 9 episode visits * 32 subjects			$ 7,200	
"On-call" subjects @ $30 * 32 subjects			$ 960	
Pager Rental (on call) @ $25 * 2 visits * 16 subjects			$ 800	
Pager Return Bonus @ $10 * 32 subjects			$ 320	$ 22,580
Travel				
Travel of Liu to conduct site visit	$ 400	Travel of coordinator to Pullman	$ 1,200	
Lodging, 2 months, $800/mon	$ 1,600	per-diem @ $25/day x 60 d	$ 1,500	
Airfare between Seattle and Spokane @ $200 * 8 trips + parking/taxies $40 * 8			$ 1,920	
Rental Car @ $50.00 * (2 days * 6 trips + 2 days * 2 coordinator trips)			$ 800	
Per Diem (meals) @ $30 * 12			$ 360	
Per Diem (meals) @ $48 * 4			$ 192	
Lodging (Pullman) @ $55 * 6 trips			$ 330	
Lodging (Seattle) @ $109 * 2 trips			$ 218	$ 8,526
WSU Subcontract (Salaries total)				
Total Budget				$ 52,530
Subtotal Direct Costs				$ 178,569
IDC (less equipment and graduate operating fee) at	26%			39,270
			Total Costs	$ 217,840